

# Indium-mediated reductive dehalogenation of $\alpha$ -halocarbonyl compounds in water †

Leeyoung Park,<sup>a</sup> Gyochang Keum,<sup>a</sup> Soon Bang Kang,<sup>a</sup> Kwan Soo Kim<sup>b</sup> and Youseung Kim<sup>\*a</sup>

<sup>a</sup> Biochemicals Research Center, Korea Institute of Science and Technology, Cheongryang P.O. Box 131, Seoul 130-650, Korea.

E-mail: yosekim@kistmail.kist.re.kr; Fax: +82-2-958-5189

<sup>b</sup> Department of Chemistry, Yonsei University, Seoul 120-749, Korea

Received (in Cambridge, UK) 3rd July 2000, Accepted 27th October 2000

First published as an Advance Article on the web 30th November 2000

Reactions of various  $\alpha$ -halocarbonyl compounds **1** with indium in the presence of a catalytic amount of sodium dodecyl sulfate in water were performed to afford the corresponding parent carbonyl compounds **2** in excellent yields.

## Introduction

Recently, organic reactions that can be carried out in aqueous media have become one of the most challenging areas in organic synthesis due to the environmental benefits and favorable effects of water on chemical transformations.<sup>1</sup> Especially, the reactions mediated by indium in aqueous media are of current interest for their considerable applications in organic synthesis.<sup>2,3</sup>

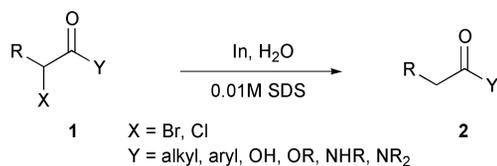
While the reductive dehalogenation reactions of  $\alpha$ -halocarbonyl compounds **1** using various reagents such as active metals, low-valent metals, metal hydrides, or halide salts in organic solvents have been studied extensively,<sup>4,5</sup> only a quite limited number of procedures have been reported to be conducted in aqueous media. These known methods are effective with limited carbonyl functional groups,<sup>6,7</sup> using sonication,<sup>8</sup> or suffer from low yields<sup>9</sup> of products.

Our continuous efforts<sup>10</sup> to explore the utility of indium metal for organic synthesis in mild conditions led us to find that  $\alpha$ -halocarbonyl compounds **1** can be effectively reduced to the

sodium dodecyl sulfate (SDS) in water from room temperature to 80 °C for the time required to complete the reaction yielded the corresponding carbonyl compounds **2** in excellent yields. As shown in Table 1, this dehalogenation procedure is effective not only with  $\alpha$ -haloketones, esters and acids but also with amide compounds. Even the hindered compound, 3-bromobornan-2-one was efficiently dehalogenated at 60 °C for 3 h in 96% yield (entry c). In the case of  $\alpha$ -chlorocarbonyl compounds, the reaction was rather slow compared with the bromo compounds and a slightly higher temperature was required. An aliphatic  $\alpha$ -bromoacid compound was reduced to the parent acid by addition of 1 drop of 2 M HCl (entry h). Also dehalogenation of  $\alpha$ -halonitrile compounds was successfully achieved under these reaction conditions as shown in Table 1 (entries m–o).

To our knowledge this is the first report on dehalogenation of  $\alpha$ -halonitrile compounds in H<sub>2</sub>O. Without SDS as a surfactant, the reactions proceeded slowly and most of the starting materials in some cases were recovered after prolonged reaction. The use of such micellar systems<sup>12</sup> as reaction media gave rise to remarkable rate enhancement.

In conclusion, we have developed a versatile, effective and convenient dehalogenation procedure for converting various  $\alpha$ -halocarbonyl compounds **1** to the parent carbonyl compounds **2** in water in excellent yields. The present dehalogenation reaction offers a simple and easily performed alternative to other known methods. These micellar systems may also be applied to other indium-mediated reactions in water.



Scheme 1

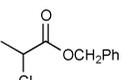
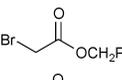
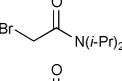
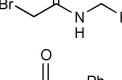
parent carbonyl compounds **2** in a reaction mediated by indium in the presence of sodium dodecyl sulfate (SDS) in water. This is the first case in which indium-mediated reductive dehalogenation of  $\alpha$ -halocarbonyls is carried out in micellar systems.<sup>11</sup> We wish to report herein the versatile and efficient dehalogenation method of various  $\alpha$ -halocarbonyl compounds **1** using indium in water.

## Results and discussion

Treatment of the  $\alpha$ -halocarbonyl compounds **1** with 130–170 M% of indium powder (~100 mesh) in the presence of 1 M% of

† Details of the synthesis and analytical data for  $\alpha$ -halocarbonyl compounds **1a**, **1i**, **1j** and **1l–1o** are available as supplementary data. For direct electronic access see <http://www.rsc.org/suppdata/p1/b0/b005278g/>

**Table 1** Reductive dehalogenation of various  $\alpha$ -halocarbonyl compounds with indium metal in H<sub>2</sub>O

Entry	$\alpha$ -Halocarbonyl compounds <b>1</b>	Temp./ °C	In H <sub>2</sub> O		0.01 M SDS in H <sub>2</sub> O	
			Time/ h	Yield (%) <sup>d</sup>	Time/ h	Yield (%) <sup>d</sup>
a		80	6	94 <sup>e</sup>	3	>99
b		60 <sup>a</sup>	5	94 <sup>e</sup>	4	96
c		60	24	4 <sup>e</sup>	3	96 <sup>e</sup>
d		50	7	NR <sup>f</sup>	6	88 <sup>e</sup>
e		60 <sup>b</sup>	2	51 <sup>e</sup>	0.5	>99
f		rt	3	53	1	90
g		rt	7	71	1	83
h		rt <sup>c</sup>	3	88 <sup>e</sup>	1	>99
i		rt	7	99	4	>99
j		rt	48	NR <sup>f</sup>	20	>99
k		60 <sup>a</sup>	48	NR <sup>f</sup>	5	94 <sup>e</sup>
l		rt	6	>99	3	86
m		60 <sup>a</sup>	30	97 <sup>e</sup>	30	>99
n		rt	24	29 <sup>e</sup>	6	>99
o		60	3	79 <sup>e</sup>	1	>99

<sup>a</sup> 1.7 eq. of indium were used. <sup>b</sup> 1.3 eq. of indium were used. <sup>c</sup> 1 drop of 2 M HCl was added. <sup>d</sup> Isolated yield. <sup>e</sup> NMR yield. <sup>f</sup> No reaction.

#### General method for the reductive dehalogenation of $\alpha$ -halocarbonyl compounds<sup>†</sup>

**Acetophenone (2b).** To a stirred 0.01 M aqueous solution (0.5 cm<sup>3</sup>) of SDS,  $\alpha$ -bromoacetophenone **1b** (99.5 mg, 0.5 mmol)

and indium powder (86.1 mg, 150 M%) were added. The solution was heated to 60 °C for 4 h, and water (2 cm<sup>3</sup>) was added. The solution was extracted with chloroform (5 × 3 cm<sup>3</sup>), and the solution was concentrated under reduced pressure after drying over MgSO<sub>4</sub>. The oily residue was purified by filtration over a short column of silica gel using *n*-hexane–ethyl acetate (6:1) as eluant to give 57.3 mg (96%) of acetophenone **2b** as a colorless oil after evaporation of the solvent. The product was identical in all respects with an authentic sample.

#### Acknowledgements

This work was fully supported by the Korea Institute of Science and Technology and the Ministry of Science and Technology.

#### References

- For a review, see: G. A. Molander, *Chem. Rev.*, 1992, **92**, 29; C. J. Li, *Chem. Rev.*, 1993, **93**, 2023; A. Lubineau, J. Aug and Y. Queneau, *Synthesis*, 1994, 741; C. J. Li and T. H. Chan, *Organic Reactions in Aqueous Media*, Wiley, New York, 1997; P. A. Grieco, *Organic Synthesis in Water*, Blackie Academic & Professional, London, 1998.
- T. H. Chan, C. J. Li, M. C. Lee and Z. Y. Wei, *Can. J. Chem.*, 1994, **72**, 1181; P. Cintas, *Synlett*, 1995, 1087.
- C. J. Li and T. H. Chan, *Tetrahedron*, 1999, **55**, 11149; C. J. Li, *Tetrahedron*, 1996, **52**, 5643; C. J. Li, D. L. Chen, Y. Q. Lu, J. X. Haberman and J. T. Mague, *J. Am. Chem. Soc.*, 1996, **118**, 4216; M. Jayaraman, M. S. Manhas and A. K. Bose, *Tetrahedron Lett.*, 1997, **38**, 709; X. H. Yi, Y. Meng and C. J. Li, *Chem. Commun.*, 1998, 449; A. S. K. Hashmi, *J. Prakt. Chem.*, 1998, **340**, 84; T. P. Loh, G. Q. Cao and J. Pei, *Tetrahedron Lett.*, 1998, **39**, 1453; P. K. Choudhury, F. Foubelo and M. Yus, *Tetrahedron Lett.*, 1998, **39**, 3581.
- For a review, see: A. J. Fry, *Comprehensive Organic Synthesis*, vol. 8, ed. I. Fleming, Pergamon Press, Oxford, 1991, pp. 983–997; R. Noyori, Y. Hayakawa, *Org. React.*, 1983, **29**, 163; A. G. Sutherland, *Comprehensive Organic Functional Group Transformations*, vol 1, ed. S. M. Roberts, Pergamon Press, Oxford, 1995, pp. 1–11.
- R. Yanada, K. Bessho and K. Yanada, *Chem. Lett.*, 1994, 1279; A. D. Hughes and N. S. Simpkins, *Synlett*, 1998, 967; B. C. Ranu, S. K. Guchhait and A. Sarkar, *Chem. Commun.*, 1998, 2113; Y. Han and Y. Z. Huang, *Tetrahedron Lett.*, 1998, **39**, 7751.
- A. L. Gemal and J. L. Luche, *Tetrahedron Lett.*, 1980, **21**, 3195; A. Ono, E. Fujimoto and M. Ueno, *Synthesis*, 1986, 570; A. Ono, J. Kamimura and N. Suzuki, *Synthesis*, 1987, 406; C. J. Rizzo, N. K. Dunlap and A. B. Smith III, *J. Org. Chem.*, 1987, **52**, 5280; M. Penso, S. Mottadelli, D. Albanese, *Synth. Commun.*, 1993, **23**, 1385; D. O. Jang, *Tetrahedron Lett.*, 1996, **37**, 5367.
- T. H. Chan, C. J. Li and Z. Y. Wei, *J. Chem. Soc., Chem. Commun.*, 1990, 505; H. Kagoshima, Y. Hashimoto, D. Oguro, T. Ktusuna and K. Saigo, *Tetrahedron Lett.*, 1998, **39**, 1203.
- B. C. Ranu, P. Dutta and A. Sarkar, *J. Chem. Soc., Perkin Trans. 1*, 1999, 1139.
- W. Bao and Y. Zhang, *Synlett*, 1996, 1187.
- H. J. Lim, G. Keum, S. B. Kang, B. Y. Chung and Y. Kim, *Tetrahedron Lett.*, 1998, **39**, 4367; H. J. Lim, G. Keum, S. B. Kang, B. Y. Chung and Y. Kim, *Tetrahedron Lett.*, 1999, **40**, 1547; J. Yoo, K. E. Oh, G. Keum, S. B. Kang and Y. Kim, *Polyhedron*, 2000, **19**, 549; H. Chae, S. Cho, G. Keum, S. B. Kang, A. N. Pae and Y. Kim, *Tetrahedron Lett.*, 2000, **41**, 3899.
- S. Kobayashi, T. Busujima and S. Nagayama, *Chem. Commun.*, 1998, 19.
- S. Taciolu, *Tetrahedron*, 1996, **52**, 11113.